African Invertebrates Vol. 43 Pages 00–00 Pietermaritzburg December, 2002

Gulella salpinx sp. n., a new critically endangered holoendemic species from the limestone deposits of the Marble Delta, KwaZulu-Natal, South Africa (Mollusca: Gastropoda: Streptaxidae)

by

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ABSTRACT

Gulella salpinx sp. n. is described from a limestone habitat near Port Shepstone, KwaZulu-Natal. Details of shell morphology, radula and genital anatomy, including penial armature are provided. The species is ovoviviparous and is unusual amongst *Gulella* species in having a continuous, flaring peristome. It shows no clear affinity with any other southern African species in the genus. It is known only from a single small locality within the Marble Delta, and is almost certainly restricted to this geological formation on account of specific habitat requirements related to soil chemistry. The integrity and continued persistence of natural habitats in this area are at risk due to mining and the invasion of alien plants. The species evidently meets the criteria for red-listing as critically endangered.

INTRODUCTION

Terrestrial molluscan faunas associated with limestone deposits are known to be rich, both in terms of abundance and species richness (Peake 1978; Little 1998). In addition, such habitats often contain narrow range endemic land snails restricted to individual outcrops on account of habitat specialisation related to the local edaphic characteristics — holoendemic species (Richardson 1978; Van Wyk & Smith 2001). Examples of this can be found in Cuba, Jamaica, Central America, Madagascar, Malaysia, Borneo, Papua New Guinea and Australia, and many other parts of the world (Tweedie 1961; Purchon 1968; Solem 1974; Andrews & Little 1982; Stanisic 1990 1994 1997; Schilthuizen 2001). The malacofauna of limestone areas in southern Africa has not been systematically studied and there is no information regarding any associated increase in molluscan abundance, species diversity and endemicity. I have previously identified them as a priority area for future field-work in the region (Herbert 1998). Within KwaZulu-Natal, deposits of limestone are not common (Martini 1987). The only regions where significant deposits occur are in the Marble Delta, inland of Port Shepstone, and in Zululand, in a narrow belt running north from the Mtubatuba area, along the eastern edge of the Ubombo and Lebombo Mountains. The latter deposits, however, are for the most part well-buried and rarely crop out. Although additional smaller deposits occur in and around the central Thukela basin, the Marble Delta stands out as the largest and most important limestone outcrop in the province. It has been exploited to varying degrees since 1866, and is now quarried by two large scale commercial operations.

In an attempt to remedy the dearth of knowledge relating to the calcicolous malacofauna of southern Africa, I have recently undertaken a series of field-trips to the Marble Delta. The aim of this study is to document the malacofauna associated with the deposit and assess its abundance, diversity and levels of endemicity, at the same time

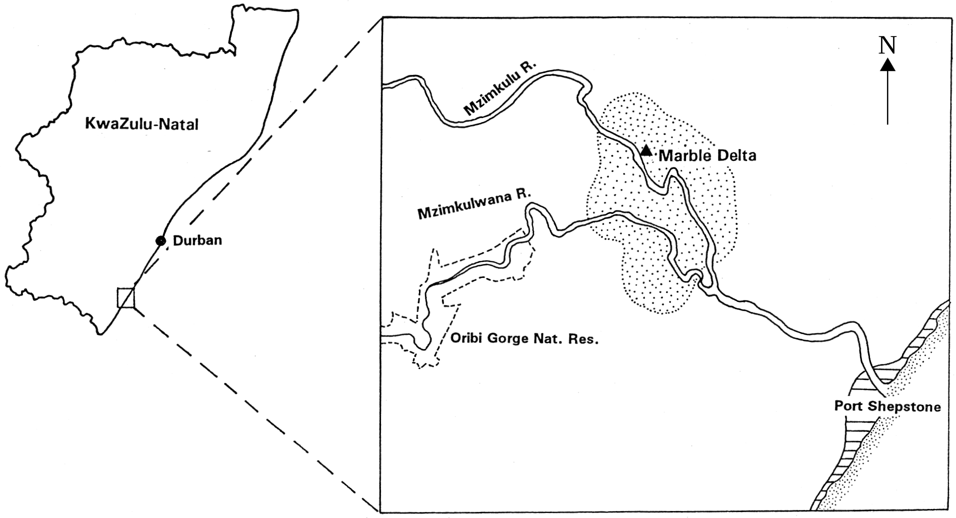


Fig. 1. Map of Port Shepstone area and coastal hinterland, showing location of Marble Delta (stippled area). The type locality of *Gulella salpinx* sp. n. is marked with a black triangle; the cross hatched area indicates the built-up coastal strip.

identifying and highlighting possible conservation priorities. The purpose of the present contribution is to describe a new, highly distinctive and evidently holoendemic species of the family Streptaxidae that was found during this field-work. As well as describing the shell and radula, I give details of the genital anatomy, including penial armature, as these structures may ultimately provide useful phylogenetic characters.

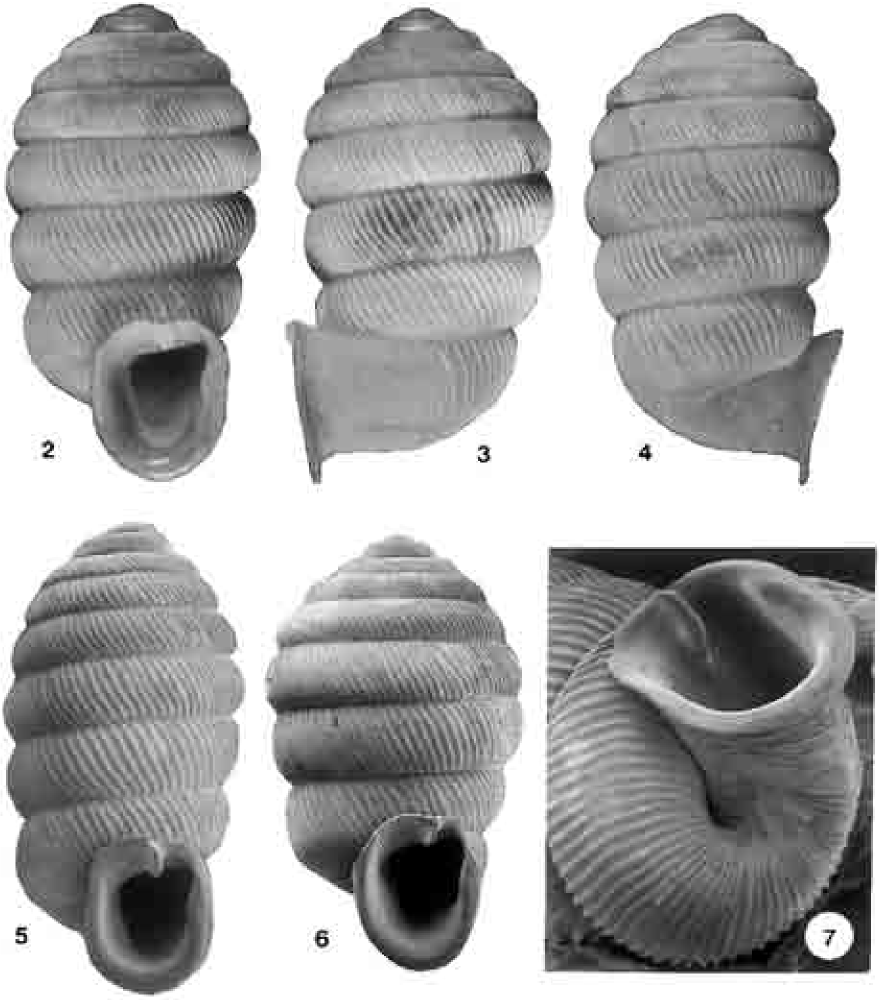
Study site (Fig.1): The Marble Delta comprises an area of *ca* 40 km^2 at the junction of the Mzimkulu and Mzimkulwana rivers, inland of Port Shepstone (30°40'S: 30°22'E). The geology and petrology of the area have been discussed in detail by Otto (1977). It consists primarily of calcitic marble, surrounded by granite, granulite and gneiss. The topography is rugged and access is difficult. The vegetation of the region falls within the thicket biome and consists mostly of valley thicket (Low & Rebelo 1996). It varies in density from almost closed canopy woodland in the stream valleys on the south-facing slopes, to somewhat more open *Acacia* thicket on the north-facing ridges. Currently, quarrying is concentrated on the south bank of the Mzimkulu River above its confluence with the Mzimkulwana River, and much of the vegetation in this area has been removed. In all areas the indigenous vegetation has been heavily invaded by alien plants, notably *Chromolaena odorata* (L.) R. M. King (Asteracea), and *Lantana camara* L. (Verbenacea), both from south and central America.

TAXONOMY

Gulella salpinx sp. n.

(Figs 1–24)

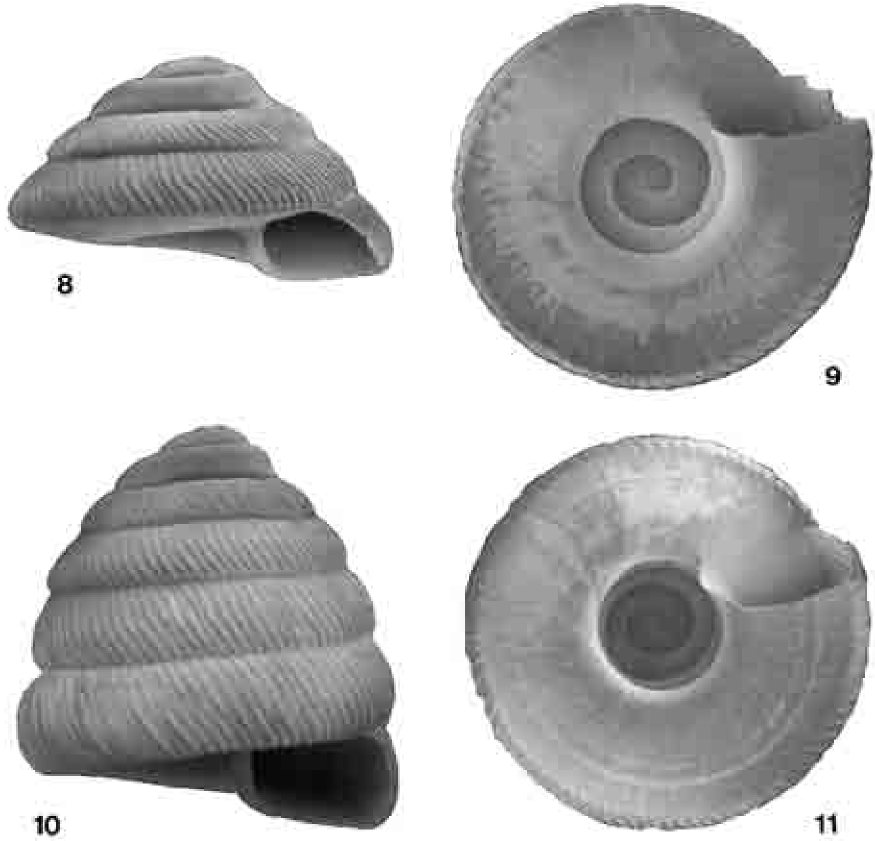
Diagnosis: Shell of moderate size, length 6.70–7.55 mm, cylindrical to somewhat obovate; sculptured with strong axial ribs; peristome entire and disjunct from preceding whorl, strongly flaring; aperture with a single tooth, a weak in-running parietal lamella;



Figs 2–7. *Gulella salpinx* sp. n. 2–4. Holotype, length = 7.14mm. 5. Paratype, cylindrical specimen, length = 6.97mm. 6. Paratype, squat, obovate specimen, length = 6.56mm. 7. Paratype, oblique basal view to show umbilicus.

umbilicus narrow. Radula with relatively few teeth (*ca* 1750), rachidian present. Penis short and stout, lacking strong spines or hooks, but with three distinct series of minute spinules. Ovoviviparous.

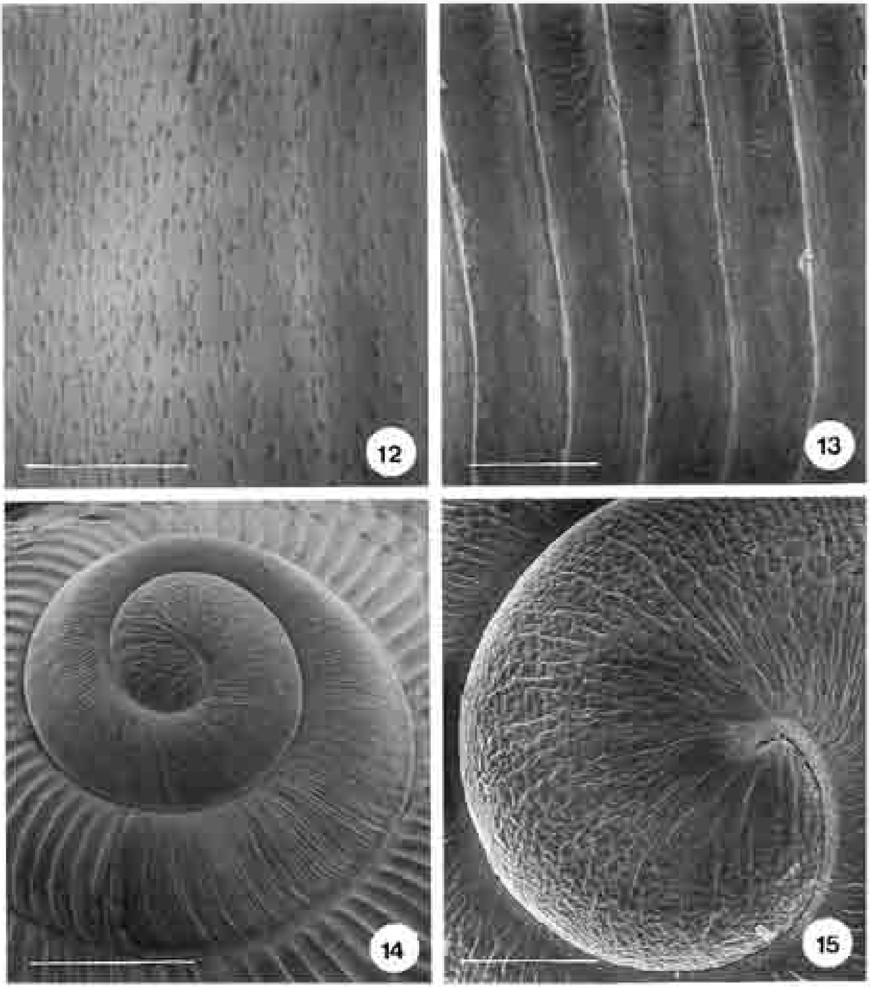
Description: Shell of moderate size for the genus, length 6.70–7.55 mm (mean=7.161, n = 21), width 3.57–3.98 mm (mean = 3.799, n = 21), length/diameter ratio 1.71–2.07; rather variable in shape, from cylindrical (Fig. 5) to obovate-cylindrical (Fig. 6), with the broadest part between middle region and apex; diameter of last and penultimate whorls often distinctly smaller than middle whorls. Embryonic shell (Fig. 14) *ca* 1.6 mm in diameter, comprising *ca* 2.5 whorls; initial whorl with somewhat irregular wrinkle-like sculpture (Fig. 15), this becoming progressively more radially (axially) aligned in subsequent whorls and appearing



Figs 8–11. *Gulella salpinx* sp. n. 8–9. Paratype, 4-whorled juvenile, apertural and basal views, diameter 3.40mm. 10–11. Paratype, 7-whorled juvenile, apertural and basal views, diameter 3.78mm.

as very fine, close-set axial riblets on final embryonic shell whorl; junction between embryonic shell and teleoconch distinct. Teleoconch comprising 6.25–7.00 whorls; whorls moderately to strongly convex, suture indented; sculptured by stronger, prosocline axial ribs, running from suture to suture (55–70 on penultimate whorl); rib intervals lacking obvious microsculpture and with no evidence of spiral threads (Fig. 13); base of juvenile shells lacking axial ribs (Figs 9, 11), sculptured instead by fine, somewhat irregular, raised axial threads (Fig. 16).

Terminal part of last whorl disjunct from preceding whorl and drawn out into a short trumpet-like tube (Fig. 3); length of tube somewhat variable; peristome entire in mature individuals and aperture with only a single tooth, viz.: a simple, rather weak parietal lamella in the form of an in-running ridge, commencing at lip edge and running inward to level of basal part of preceding whorl (Fig. 7); in addition, mid portion of outer lip usually thickened, forming a low bulge one half to two-thirds length of lip from base; peristome at most slightly indented to right of parietal lamella. Interior of aperture appearing smooth, but microscopically sculptured with minute raised granules (Fig. 12). Juveniles lacking apertural dentition at all stages (Figs 8, 10). Exterior of body whorl with a shallow spiral indentation between periphery and base (Fig. 3), giving

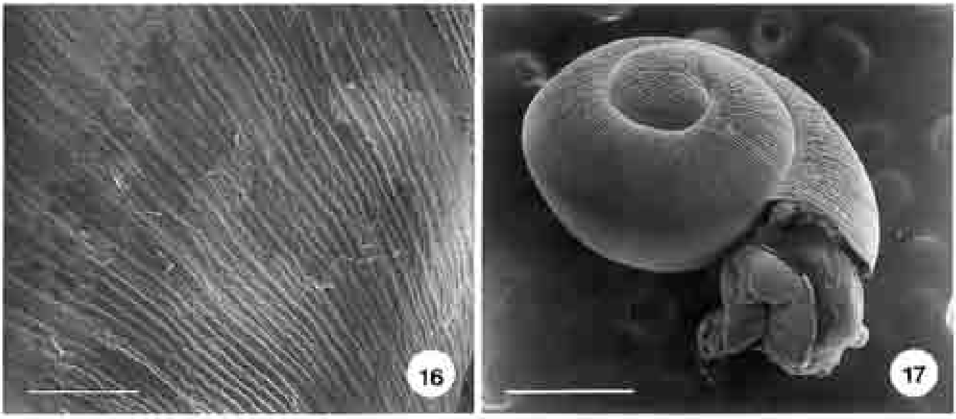


Figs 12–15. *Gulella salpinx* sp. n. 12. Paratype, granular microsculpture inside aperture, scale bar = 50µm. 13. Intervals between axial ribs, scale bar = 200µm. 14. Paratype, embryonic shell, scale bar = 0.5 mm. 15. Paratype, first whorl of embryonic shell, scale bar = 200µm.

base a slightly constricted, 'pinched-in' appearance; indentation not underlying an in-running internal palatal ridge/fold, and disappearing immediately behind flaring aperture lip.

Umbilicus open in adult (Fig. 7), but not wide, oval to drop-shaped; much wider and more circular in juvenile specimens (Figs 9, 11); widest in specimens of *ca* 2.0 teleoconch whorls and constituting 35–45 % of total shell width; umbilical diameter gradually narrowing with the addition of succeeding whorls, from *ca* 1.2 mm at its widest, to less than 0.5 mm in penultimate whorl.

Shell uniformly white, at most slightly translucent even when fresh; but much of shell surface usually covered with what appears to be a flaky periostracal layer encrusted with microscopic leaf-litter particles. Animal uniformly off-white to pale buff (Fig.



Figs 16–17. *Gulella salpinx* sp. n. 16. Axial microsculpture on base of juvenile, scale bar = 100µm. 17. Embryo *ex utero*, scale bar = 0.5 mm.

18), somewhat translucent; upper tentacular retractor muscles bright orange, clearly visible through neck and tentacle wall when extended.

Radula (Figs 19–22): Beloglossan, length *ca* 2.1 mm, with *ca* 53 broadly v-shaped, transverse rows of backward-pointing teeth; formula (15–17)+1+(15–17); total number of teeth *ca* 1750. Rachidian tooth present, but small, with a flattened, ovate base plate and a short claw-like cusp (Fig. 22); inner lateral teeth progressively larger, reaching a maximum at teeth four and five (tooth length *ca* 50 µm), then decreasing to less than half this size at edge of radula (Fig. 20); no obvious distinction between lateral and marginal teeth; cusp of larger lateral teeth at least as long as the base plate (Fig. 21),

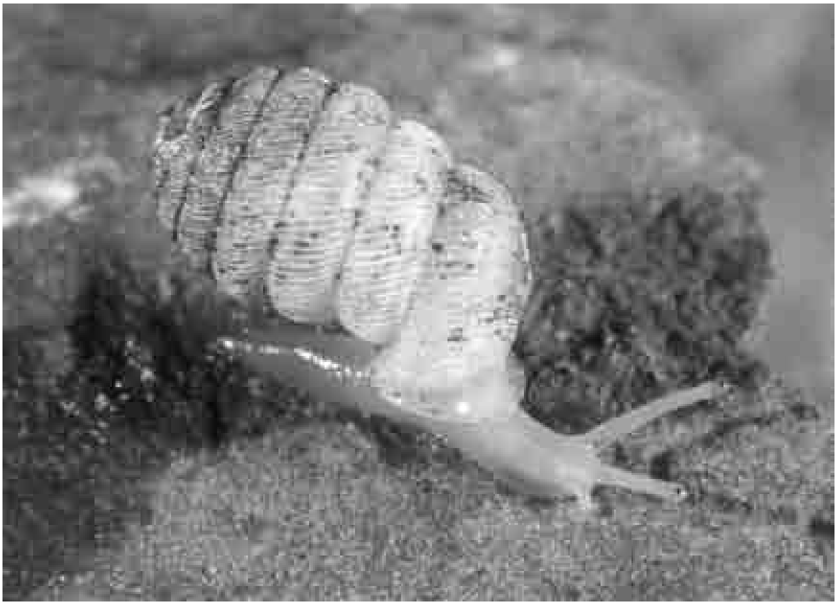
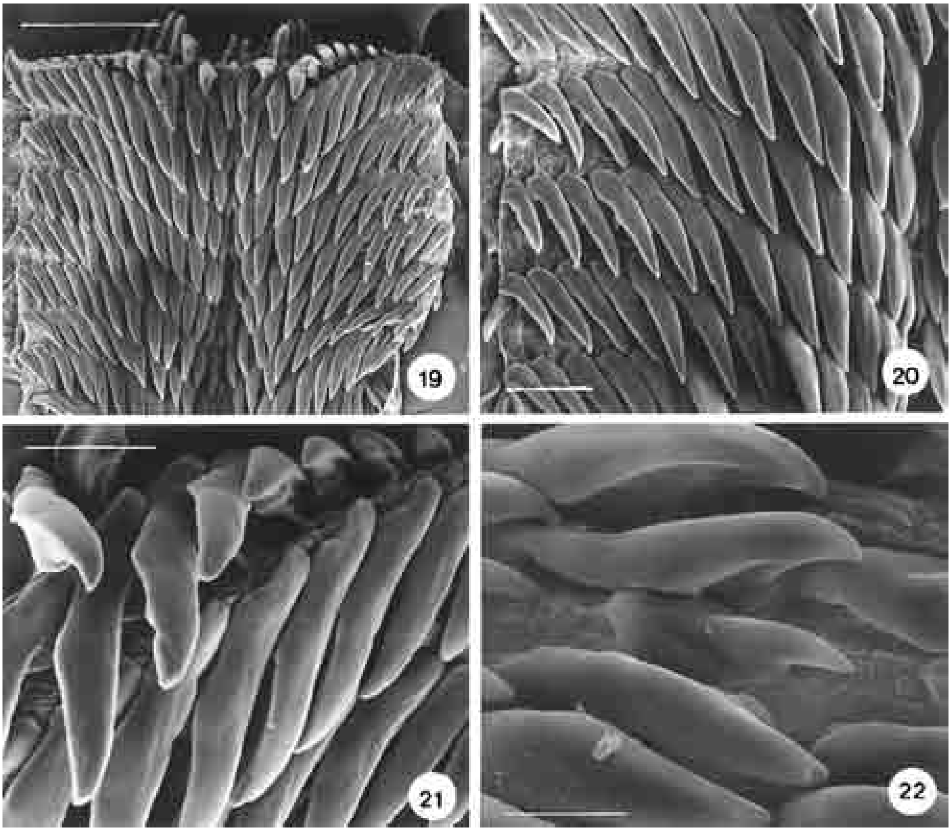


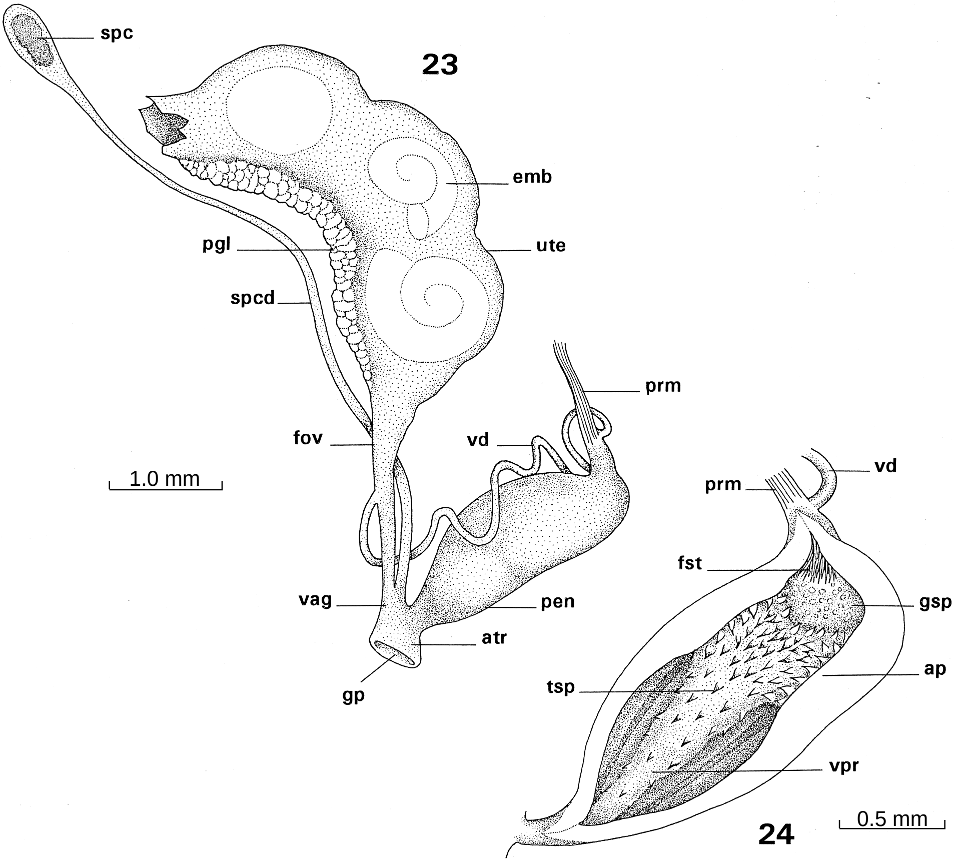
Fig. 18. *Gulella salpinx* sp. n., living animal, shell length *ca* 7.2 mm.



Figs 19–22. *Gulella salpinx* sp. n. radula. 19. Active zone of radula at anterior odontophoral flexure, scale bar = 75µm. 20. Half-row of preceding edge of radula folded under and outermost 2–4 teeth not visible, scale bar = 25µm. 21. Zone of lateral maximum, showing basal attachment and elongate shaft/cusp, scale bar = 20µm. 22. Rachidian and shorter, innermost lateral teeth, scale bar = 10µm.

those of inner two and outermost laterals shorter; teeth somewhat curved, the medio-ventral surface concave, so as to accommodate the inner neighbour when folded (Fig. 22); largest laterals distinctly knife-like in dorsal view. Basal peg anchoring tooth to radula membrane (cf. Aiken 1981) not visible under SEM, but evident in light microscope preparations stained with Shirlastain A.

Genital morphology (Figs 23, 24): The penis is stout and muscular, 1.5–2.0 mm in length (not everted). At its proximal (innermost) end it narrows rapidly toward its junction with the vas deferens, which is terminal and lies at a point adjacent to the insertion of the penial retractor muscle. The latter is undivided and well developed. An epiphallus or epiphalloid sac is not apparent and there is no penial sheath or appendix. The vas deferens is long and sinuous, winding forward beneath and alongside the penis before crossing under the spermathecal duct and free oviduct, after which it passes posteriorly again before joining the free oviduct, approximately halfway between the vagina and the anterior end of the thickened portion of the sperm-oviduct. The distal two-thirds of the vas deferens, nearest to the penis, appears thick-walled and muscular, whilst the



Figs 23–24. *Gulella salpinx* sp. n. Distal reproductive tract and internal penial armature. 23. Distal reproductive tract. 24. Dissection of penis to reveal internal armature; the wall of the penis has been cut longitudinally in the dorso-lateral area and the cut walls spread apart. **ap**, annular pilaster; **atr**, atrium; **emb**, embryo; **fov**, free oviduct; **fst,** fibrous spinule tuft; **gp**, genital pore; **gsp**, granular spinules; **pen**, penis; **pgl**, prostate gland; **prm**, penial retractor muscle; **spc**, spermatheca; **spcd**, spermathecal duct; **tsp**, trigonal spinules; **ute**, uterus; **vag**, vagina; **vd**, vas deferens; **vpr**, ventral pilaster ridge.

proximal third, closest to its junction with the free oviduct, is thinner and more delicate. The spermatheca (bursa copulatrix) is ovate with an orange-brown mass inside. It lies posterior to the beginning of the sperm-oviduct, embedded within the apical viscera; its duct is long, running forward close to the columella and adjacent to the sperm-oviduct, distally it is closely applied to the free oviduct, inserting near to where the latter fuses with the genital atrium. The male and female components of the sperm-oviduct, the spermiduct and the oviductal channel, are separate, the distal part of the oviductal channel being in the form of a uterus, which in some individuals contained 2–3 eggs/embryos at various stages of development (early summer). The largest observed comprised nearly 2.5 whorls, i.e. almost the entire embryonic shell (Fig. 17).

The internal structure of the penis is complex (Fig. 24). In the proximal (innermost) third the wall is thickened forming an annular pilaster, in the ventral region this continues forward toward the genital atrium as a broad, slightly raised longitudinal ridge. Some variation is evident in the shape of the pilaster and in one specimen part of it was raised, forming a mushroom-like papilla. Penial armature is complex. The bulk of the pilaster bears close-set, elongate-trigonal spinules, mostly directed toward the genital opening. They are relatively easy to pick out on account of their orange colour. Similar, but smaller and more sparsely distributed spinules continue distally along the ventral pilaster ridge. On either side of this, the penial wall bears shallow, irregular longitudinal ridges and lacks spinules. The narrow section of the penis, near its junction with the vas deferens, contains a tuft of elongate fibre glass-like spinules. Between this and the annular pilaster is a zone of extremely small, granule-like spinules. In the everted penis the spines will lie mostly toward the tip of the penis and be directed backwards. These almost certainly function as hold-fast devices during copulation, preventing premature withdrawal of the everted penis from the partner. The elongate spinules near the opening of the vas deferens will presumably project as tuft at the tip of the everted penis.

Type material: Holotype: NMSA V9856/T1877, length 7.14 mm, width 3.98 mm. KwaZulu-Natal, Marble Delta, immediately upstream of confluence of Mzimkulu and Mzimkulwana rivers, between Port Shepstone and Oribi Gorge Nature Reserve, on northern bank of Mzimkulu River (30°39.056'S:30°21.361'E), leg. D. Herbert & M. Bursey, 5.x.2001 and 5.xii.2001.

Paratypes (39): NMSA V9857/T1878, same locality as holotype, leg. D. Herbert *et al.* 05/x/2001 and 05/xii/2001. One paratype from this series has been deposited at each of the following institutions: Nationaal Natuurhistorisch Museum, Leiden (RMNH 93036); National Museum of Wales, Cardiff (NMW Z.2002.055.00001.); Natural History Museum, London (BMNH 20020252); National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM 1004625).

Distribution and habitat (Fig. 1): Known only from the type locality which comprises dense valley thicket/woodland, heavily invaded with *Chromolaena odorata* and *Lantana camara*. Living under logs and in leaf-litter beneath trees and dense understorey shrubs. All specimens were found in an area approximately 50 m X 20 m. At the time of sampling, the species was moderately common at this locality and shells, both alive and dead, could be found with ease. Standard fertility analysis of soil samples indicate the pH to be 5.9, with a calcium concentration of *ca* 4000 mg/l.

Etymology: from *salpinx* (Gr.) f., a trumpet, in reference to the disjunct, flaring peristome.

DISCUSSION

I refer this new species to *Gulella* Pfeiffer, 1856, but I do so somewhat hesitantly and refrain from assigning it to any of the described subgenera, as none appears to be obviously appropriate. The species is unique amongst the southern African streptaxids in having an uninterrupted peristome and a tubular, flaring apertural margin. Indeed, I know of no streptaxids from continental Africa with which it shows obvious affinity. I refer it to *Gulella sensu lato*, simply because its axially ribbed, subcylindrical shell with relatively small body whorl, undistorted axis and reflected apertural rim, seems closest to that genus. Certainly it appears referable to the Ptychotrematinae rather than the Streptaxinae, although it lacks the spiral palatal folds/ridges typical of *Ptychotrema* Pfeiffer, 1853.

Superficially, *Gulella salpinx* most closely resembles species of *Gonospira* (*Microstrophia*) Möllendorff, 1887, from the Mascarene Islands and Madagascar, in particular the type species *G.* (*M.*) *clavulata* (Lamarck, 1822) and *G.* (*M.*) *cariei* (Germain, 1921) [= *G.* (*M.*) *modesta* H. Adams 1867, *fide* Madge 1938]. Indeed, in view of the disturbed nature of the Marble Delta habitat and the proximity of sugarcane plantations in Oribi Flats, it occurred to me initially, that the species may even be a *Microstrophia*, introduced from Mauritius. In species of *Microstrophia*, however, there is a distinct hiatus in the peristome, to the right of the parietal lamella, such that the outer lip joins the preceding whorl, rather than being confluent with the parietal lip and lamella (see illustrations in Griffiths 2000). Furthermore, in *Microstrophia*, the axial sculpture is stronger and more widely spaced (35–45 ribs on the penultimate whorl in *G.* (*M.*) *clavulata* and 30–40 in *G.* (*M*) *modesta*); the embryonic shell comprises 2.75 whorls (rather than 2.50) and is not obviously axially sculptured, being instead densely micropustulate; there is no spiral indentation on the base, but there may be distinct traces of spiral sculpture in the rib interstices. The Asian genus *Sinoennea* Kobelt, 1904 (type species *Pupa strophiodes* Gredler, 1881), also shows some similarity in terms of the complete peristome, but generally has a more deeply in-running parietal lamella, a distinct columella lamella, stronger labral dentition and possesses apertural dentition in the juvenile stages (Jutting 1961). The similarities between the present species and both *Microstrophia* and *Sinoennea* are probably the result of convergence rather than close common ancestry. To assign *G. salpinx* to either of these two genera would have biogeographical implications that may not be justified.

Whilst descriptions of radulae are available for many streptaxid species, no generic synthesis of radula morphology has been undertaken and no phylogenetically informative radula characters have yet been identified within the family. Aiken (1981) delimited three basic radula types in *Gulella*, but there is little indication that these are linked to distinct clusters of related taxa. With only *ca* 53 rows of teeth, the radula of *G. salpinx* is relatively short. A number of other streptaxids have radulae with over 100 rows of teeth, some such as *Gulella menkeana* (Pfeiffer, 1853) (type species of the genus) with more than 200 rows (pers. obs.). Similarly, the number of teeth per half-row is low in *G. salpinx*, some other species having 40 or more. With respect to the three radula types described by Aiken (1981), *G. salpinx* can most easily be identified with ‘Group A’, having relatively few teeth in total (*ca* 1750), a basal, peg-like anchor on each tooth and a lateral tooth maximum some distance from the rachidian. However, in this group the basal attachment of each tooth is longer than the cusp, and although this may be true for the innermost and outermost teeth in *G. salpinx*, the cusp of the longer laterals is at least as long as the basal attachment. In streptaxids as a whole, the rachidian is reduced, but it nonetheless retains a distinct cusp in *G. salpinx*.

The structure of the male genitalia of *G. salpinx* is relatively simple (there being no penial appendages, penis sheath or discrete epiphallus), and with respect to the apical insertion of the penial retractor muscle and vas deferens, the species resembles many streptaxid taxa (Degner 1934; Verdcourt 1961 1990; Schileyko 2000). Gerlach & Bruggen (1999) stated that *Gulella* species ‘may perhaps be characterised by having a short, club-shaped penis’. However, whilst the penis of *G. salpinx* is indeed short, that of *G. menkeana* (type species of the genus), is much longer and more slender (pers. obs.). Verdcourt (1990) speculated that penial ornamentation (armature) may ‘ultimately prove to be the most valuable character' for determining relationships within the Streptaxidae, but bemoaned the lack of comparative data. Although the situation is somewhat better today (cf. Schileyko 2000), we are still unable to identify phylogenetically meaningful characters in penis morphology and armature (if indeed they exist).

Many streptaxid taxa from a range of genera (including some members of the Ptychotrematinae and species referred to *Gulella* itself), in addition to the more numerous spinules, have one or more large, well-developed penial spines or hooks, sometimes visible through the penis wall (Degner 1934; Ortiz de Zárate & Ortiz de Zárate 1956; Verdcourt 1979; De Winter, Gomez & Prieto 1999; Gerlach & Bruggen 1999; Tattersfield 1999; Schileyko 2000). However, the penial armature of *G. salpinx* consists only of small spinules, in which respect it resembles *G. excruciata* Connolly, 1931, *G. ngorogoroensis* Verdcourt, 1985, and *G. ingloria* (Preston, 1913) (Verdcourt 1985 1987) and *G. cavidens* (Martens, 1876) (Degner 1934). Similar, fine penial armature has also been recorded in several species of *Ptychotrema* (Degner 1934; Ortiz de Zárate & Ortiz de Zárate 1956; Verdcourt, 1990), *Streptostele lenta* (Smith, 1903) (Verdcourt 1982) and *Gonaxis enneoides* (Martens, 1878) (Adam 1965). However, in *G. salpinx* the differentiation of the teeth into three types, each occurring in distinct regions, is more obvious and possibly characteristic, as perhaps also is the annular nature of the penial pilaster.

The distal female reproductive tract is likewise simple and typically streptaxid, except for the hypertrophy of the distal portion of the oviductal channel into a uterus, in which the fertilised eggs are retained and the embryos develop to a late stage (evidently post-hatching). With such an ovoviviparous reproductive strategy, the shell aperture of the adult must permit the escape of young snails. Apertural barriers would obstruct this, and thus the aperture of *G. salpinx* has only a single small tooth. Information on the reproductive biology of streptaxids is extremely limited, but a number of instances of ovoviviparity have been reported — *Gonaxis maugerae* Gray, 1837 (Degner 1934), *Streptostele lenta* (Smith, 1903) and *S. acicula* (Morelet, 1877) (Verdcourt 1982; Schileyko 2000), *Ptychotrema upembae* Adam, Bruggen & Van Goethem, 1993) (Adam *et al*. 1993), and *Sinoennea kanchingensis* Tomlin, 1948 and *Oophana diaphanopepla* Jutting, 1954 (Berry 1963). In these also, the aperture is minimally obstructed by teeth. The majority of *Gulella* species with well developed apertural dentition must be assumed to lay eggs that are small or to some extent flexible.

CONSERVATION

The streptaxid fauna of the KwaZulu-Natal south coast is relatively well known, having been sampled extensively during the first half of the twentieth century by Henry Burnup and a number of other local streptaxid enthusiasts. The discovery of an undescribed species in the area is thus surprising, and suggests that *Gulella salpinx* is genuinely of very limited range. It would appear to be a holoendemic taxon (*sensu* Richardson 1978; Van Wyk & Smith 2001) that has evolved in response to the environmental conditions prevailing in the Marble Delta, perhaps chiefly those associated with soil chemistry.

Much of the Marble Delta is now badly degraded as a result of mining operations and the invasion of alien plants. Mining continues in the area and the habitat of the species must thus be considered threatened. Although several sites within the Marble Delta were sampled, *G. salpinx* was found at only one, covering an area of approximately 1000 m^2. This was situated on the northern bank of the Mzimkulu River, in an area of relatively dense valley thicket/woodland that showed no signs of ever having been mined. No specimens were found in the region between the Mzimkulu and Mzimkulwana rivers, an area which has been and still is mined extensively.

With a known distribution comprising a single locality of limited extent, in an area threatened by mining and invasive plants, *G. salpinx* clearly fulfils the IUCN criteria for redlisting as 'Critically Endangered B2 a, b' (IUCN 2001). Applications to this effect will be made once the species description is published. A strong recommendation should be that mining operations not be conducted on this section of the northern bank of the Mzimkulu River, in an attempt to preserve the habitat as much as possible (acknowledging that alien plants will already have altered this to some extent). Another rare species not seen alive for many decades, namely *Trachycystis scolopendra* Melvill & Ponsonby, 1903 [Charopidae], was also found living at this locality.

Some local indigenous habitat is formally preserved at Oribi Gorge Nature Reserve, up-stream on the Mzimkulwana River (Fig. 1), but this does not lie within in the Marble Delta area and its soils, derived from decomposed granite and sandstone, have a much lower calcium content (*ca* 1500 mg/l).

ACKNOWLEDGEMENTS

I would like to thank Mary Bursey and D-J. Hodgkinson of East London, and students Greg Davies, Cindy Govender, Reshnee Lalla and Sershen Naidoo from the University of Natal, Durban, for their assistance in the field. Thanks are also due to Natal Portland Cement (Giovanni Lodeti) and Idwala Carbonates (Anesh Sampathmany) for permission to access the area and for their willing co-operation. SEM examination of the specimens was undertaken at the University of Natal, Pietermaritzburg, and the assistance of staff at the EM unit in this regard is gratefully acknowledged. Soil samples were analysed by Soil Fertility and Analysis Services, Cedara College (KwaZulu-Natal Department of Agriculture). Greg Botha of the Council for Geoscience provided useful advice on geological matters and potential sampling sites. Members of the Network of African Malacologists kindly shared their expertise in relation to *Gulella* species in sub-Saharan Africa, and Linda Davis converted my dissection sketches into quality scientific illustrations. I thank Brian Stuckenberg and Dolf van Bruggen for comments on the manuscript.

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